African Crop Science Journal, Vol. 9. No. 4, pp. 655-665, 2001
Printed in Uganda.
ISSN 1021-9730/2001 $ 4.00

INTEGRATED MANAGEMENT OF COWPEA INSECT PESTS USING ELITE CULTIVARS, DATE OF PLANTING AND MINIMUM INSECTICIDE APPLICATION

S.K. ASANTE, M. TAMO[1] and L.E.N. JACKAI[1]
CSIR, Savanna Agricultural Research Institute, P.O. Box 52, Tamale, Ghana
[1]International Institute of Tropical Agriculture, Oyo Road, PMB 5320, Ibadan, Nigeria

(Received 17 July, 2000; accepted 1 August, 2001)

ABSTRACT

Trials were conducted in Kano, northern Nigeria, during 1996 and 1997 cropping seasons to determine the influence of date of planting and two well-timed insecticides sprays on the incidence of major insect pests namely, the legume pod-borer, *Maruca vitrata* Fab., legume flower thrips, *Megalurothrips sjostedti* Trybom, complex of pod-sucking bugs and cowpea aphid, *Aphis craccivora* Koch and their effect on grain yield of elite cowpea (*Vigna unguiculata* L. Walp) cultivars from International Institute of Tropical Agriculture (IITA) breeding programme. Six cultivars were planted at 4 different dates between 13 June and 12 August 1996 whilst 12 cultivars were planted at 5 different dates between 5 June and 12 August 1997 with and without insecticide protection. Aphid infestation occurred only on cowpea planted between the first week of June and mid-July with the highest incidence recorded on crop planted in the last week of June. Cowpea planted in June flowered and podded between early to mid-August when post-flowering pests (*M. vitrata, M. sjostedti* and *Clarigralla tomentosicollis*) densities were relatively low and produced significantly higher grain yields without insecticide protection compared to other planting dates. The flowering and pod formation stages of late planted (July and August) crops coincided with the peak population densities of the three major post-flowering pests resulting in a considerable reduction of grain yield. Overall, IT90K-277-2, IT93K-734, IT93K-452-1 and IT93K-513-2 performed best whereas IT86D-719, IAR-48 and Dan Ila gave the poorest performance when unsprayed. Two insecticide sprays of Cypermethrin + dimethoate (Sherpa plus ®) (30 + 250g a.i. ha^{-1}) at but initiation and 50% flowering stages increased grain yields considerably from 225 to 900 kg ha^{-1} for cowpea planted in July and August. Cost-benefit analysis indicated that the insecticide application was more profitable for cowpea planted in late July and August than was the case when planted in June and early July. This seems to suggest that early maturing elite cultivars could escape economic damage caused by post-flowering pests when cowpea is planted early in the season. The implication of these findings to the grower and the breeding strategy at IITA is discussed in this paper.

Key Words: *Aphis craccivora*, grain yields, insecticide sprays, *Maruca vitrata*, *Megalurothrips sjostedti*, planting date, pod-sucking bugs, *Vigna unguiculata*

RÉSUMÉ

Des essais ont été conduits durant les saisons culturales de 1996 et 1997 à Kano au nord du Nigeria pour déterminer l'influence de la date de plantation et la pulverization de deux insecticides bien connus sur l'incidence des principaux insectes à savoir les boreurs des gousses des légumineuses, *Muruca vitrata* Fab., les thrips des fleurs des légumineuses, *Megalurothrips sjostedti* Trybom, le complexe des punaises pipeuses des gousses et les aphides du niébe, *Aphis craccivora* Koch et les effets sur le rendement grain des cultivars élites du niébe du programme d'amélioration de l'IITA. Six cultivars ont été plantés à quatre differentes dates entre le 13 Juin et le 12 Août 1996 alors que 12 cultivars ont été plantés à cinq differentes dates entre le 5 Juin et le 12 Août 1997 avec ou sans protection d'insecticide. L'infestation des aphides ont apparu seulement sur le niébe plantés entre la première semaine de juin et mi-juillet avec l'incidence la plus élevée observée sur les cultures plantées dans la dernière semaine de Juin. Le niébe planté en Juin a fleuri et formé des gousses entre très tôt et mi-Août quant les densités des pestes post floraison (*M. vitrata, M. sjostedt* et *C. tomentosicollis*) étaient relativement faibles et ont produit significativement des rendements grains très élevés sans insecticides comparés aux autres dates de plantation. Les stades de floraison et de formation des gousses des cultures plantées plus tard (Juillet et Août) ont coincidé avec les densités plus élevées de trois majeurs pestes pot-floraison résultant à une réduction considérable du rendement grain. En général, IT90K-277-2, IT93K-734, IT93K-452-1 et IT93K-518-2 ont été les meilleurs alors que IT86D-719, IAT-48 et Dan Ila ont eu une pauvre performance lorsqu'ils étaient no pulverisés. Les pulverizations de l'insecticide de Cypermethrin + dimethoate (Sheroa plus ^{R}) (30 + 250g a.i ha^{-1}) à l'initiation et 50% des stades de floraison ont augmenté les rendements grains considérablement de 225 à 900 kg ha^{-1} pour le niébe planté en Juillet et Août. L'analyse du coût-bénéfice a indiqué que l'application de l'insecticide était plus profitable pour le niébe planté tard en Juillet et Août plus que le cas du niébe planté en Juin et début Juillet. Ceci semble indique que les cultivars élites plus précoces pourraient échapper aux domages économiques causés par les pestes post floraison quant ils apparaissent avant dans la saison. Les implications de ces résultats pour les cultivateurs et la stratégie d'amélioration pour l'IITA sont dicutées.

Mots Clés: Cultivars élites du niébe, date de plantation, applications minimum d'insecticide, pestes d'insectes et abondance, rendement de grains

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp., is one of the most important grain legumes which is widely cultivated in semi-arid areas of the tropics and subtropics for human as well as animal consumption (Singh and van Emden, 1979). In west and central Africa, the most important cowpea growing regions in the world, cowpea constitutes the cheapest source of dietary protein for the low income sector of the population (Rachie, 1985). Cowpea leaves, green pods, green peas and dry grains are consumed as food and the haulms which contain about 20% protein are fed to livestock. However, yields at farmers level are low averaging only 50 – 350 kg ha^{-1} (Rachie, 1985; Jackai and Daoust, 1986; Mortimore *et al.*, 1997; Karungi *et al.*, 2000a). The major causes of the low yields are insect pests, diseases, parasitic weeds, drought and low soil fertility, of which insects constitute the major constraint (Singh *et al.*, 1990; Karungi *et al.*, 1999; Nampala *et al.*, 1999). The presence of many insect pest species from seedling to harvest is a feature of cowpea, although flower and pod attacking pests are the most important (Raheja, 1976; Kyamanywa, 1996; Karungi *et al.*, 2000a,b, c). Losses in grain or foliage attributed to field pests of cowpea are from 20% to almost 100% (Raheja, 1976; Singh and Allen, 1980). These high losses have contributed immensely to cowpea's subsidiary position in the farming systems of several countries in the tropics (Jackai *et al.*, 1985; Mortimore *et al.*, 1997). Control of these pests is therefore crucial to sustainable production of cowpea.

Although there are several commercial insecticides available that can control these pests and increase grain yield several fold (Taylor and Ezedinma, 1964; Booker, 1965; Amotobi, 1994, 1995), they are often too expensive for poor-resource farmers, unavailable in local markets and can also result in food contamination or environmental pollution (Karungi *et al.*, 2000a). In order to reduce both over dependence on insecticides and grain yield reduction due to insect pests damage, the search for cowpea cultivars resistant to these pests has been intensified by scientists in the International Institute of Tropical Agriculture (IITA) and other institutions notably Makerere University in Eastern Africa and Bunda College in South Africa. However, it has not, to date, been possible to find high levels of resistance and/or multiple pest resistance to certain major pests such as the legume pod-borer, *Maruca (testulalis) vitrata* F., the legume flower thrips, *Megalurothrips sjostedti* Trybom and the pod-sucking bug complex, *Clavigralla tomentosicollis* Stal, *Mirperus jaculus* Thunberg, *Nezara viridula* L. and *Anoplocnemis curvipes* Fab., although several high yielding and early maturing cultivars well-adapted to different ecological zones have been developed. Therefore, until transgenic insect-resistant cowpea has been developed through biotechnology, integrated pest management (IPM) will remain the best option to reduce risks of crop losses due to insect pests and increase grain yield for the resource poor farmers who grow, and derive a sizeable portion of their protein and part of income from cowpea. This paper reports on the effectiveness of an integrated management option that combines the use of elite cultivars, manipulation of planting/sowing date and well-timed minimum (two) insecticide sprays, in the management of major insect pests of cowpea.

MATERIALS AND METHODS

Study site, land preparation, planting and treatment. The trials were conducted at IITA Research farm at Minjibir (12° 08' N: 07°38'F) near Kano, northern Nigeria, during the main cropping season (June-October) in 1996 and 1997. An improved medium maturing (68 days) cultivar (IAR-48), susceptible to all major cowpea pests in this ecology and five elite cowpea cultivars namely, IT86D-719, IT87D-941-1, IT89KD-374-57, IT90K-277-2 and IT93K-452-1 were sown on 13 June, 27 June, 23 July and 12 August 1996. In 1997, ten elite cultivars and two checks viz. IAR-48 and Dan Ila (commonly grown local cultivar) were planted. The ten elite cultivars comprised IT93K-513-2, IT93K-273-2-1, IT94K-410-1, IT93K-596-9-12, IT86D-719, IT87D-941-1, IT89KD-374-57, IT90K-277-2 and IT93K-452-1. Planting in 1997 was done on 5 June, 29 June, 15 July and 12 August with and without insecticide protection. The field was disc harrowed, fertilised with SSP and NPK at a rate of 100 kg ha^{-1} and ridged prior to planting. A split plot design was used with planting dates as the main plot factor and cultivars as sub-plot factor. Each sub-plot measured 7 rows by 7 m long with inter and intra row spacing of 1 m and 0.25 m, respectively. There were three replicates per treatment. Four seeds were hand sown in each hill and thinned to two plants two weeks after germination. Sherpa plus® (Cypermethrin + dimethoate e.c. at 30 g + 250 g a.i. ha^{-1}) was applied to the treated plots twice, first at bud initiation (32 – 36 days after planting) and second at 50% flowering (42 – 46 days after planting).

Sampling for insect pests infestation. Five inner rows excluding 1 m row from both ends of each row were selected from each sub-plot for sampling. Target insect pests were *Aphis craccivora* Koch, *M. sjostedti, M. vitrata, C. tomentosicollis, M. jaculus, N. viridula* and *A. curvipes.* All plants in the selected five middle rows were counted and visually examined to record the number infested by aphids (incidence) and scored for severity or degree of infestation on 0 – 9 scale (where 0 = no aphids; 1 = 1 – 4 aphids; 3 = 5 – 20 aphids; 5 = 21 – 100 aphids; 7 = 101 – 500 aphids and 9 > 500 aphids (Jackai and Singh, 1988) at 5 days intervals between 15 and 35 days after germination. Thrips infestation was assessed at weekly intervals from flower bud initiation to 50% podding stage (50 – 55 days after planting). At each sampling occasion, 30 flower buds (racemes) were randomly collected from each plot and kept in vials containing 50% alcohol. The number of thrips collected per sample was then counted, under binocular microscope in the laboratory. Also, beginning from 50% flowering (42 – 46 days after planting) to first pod maturity (55 – 60 days after planting), 30 flower were collected in vials containing 50% alcohol at weekly intervals for laboratory examination for flower thrip and *M. vitrata* larvae infestation. Concurrently, proportion of lowers infested by *M. vitrata* was estimated using the rapid visual estimate (RVE) method whereby 30 flowers were collected at random from each sub-plot, opened on the spot, and examined for *M. vitrata* larvae or damage. Visual counts of adults and nympths of pod-ducking bugs were made within the five middle rows of each plot at weekly intervals beginning from podding stage till harvest. Counting was done between 1400 h and 1700 h (Hammond, 1983).

Estimate of grain yield. Dry grain yields in kilogram per unit area were estimated from five middle rows of each sub-plot excluding 1 m row from each border after the pods were threshed and winnowed. The results were extrapolated to kilogram per hectare for each cultivar at the different sowing dates.

Profit yield and benefit/costs for two sprays at different sowing dates. Increase in grain yield above no spray (unprotected) treatment was assumed to be solely due to the two insecticide applications. Therefore, partial budgeting was used to estimate profit per hectare for each cowpea cultivar at the different sowing dates. Profit was estimated by deducting total pest control cost from income derived from yield increase above no spray treatment per cultivar. Costs for land preparation, seed sowing, weed control and harvesting were not included in the partial budgeting. Benefit-cost ratio defined as the number of times the chemical control cost was recouped from the value for the increased yield was calculated as:

$$\text{Benefit-Cost ratio} = \frac{\text{Value of increased yield}}{\text{Cost of pest control}}$$

Statistical analysis. Differences in infestations by insect pests as well as grain yields between cultivars and planting dates were examined by analysis of variance (ANOVA) of a split plot design. Data in percentages were arcsine transformed before analysis. Where the ANOVA test indicated significant differences between treatments, Fisher's protected LSD was used to separate treatment means. Mann-Whitney test was used to examine the difference between the mean yields under spray and no spray treatments within a planting date.

RESULTS

Dry grain yields under no insecticide protection differed significantly ($P < 0.01$) between planting dates during both 1996 and 1997. Mean grain yields (kg ha^{-1}) across cultivars under no protection were significantly higher particularly for cowpea planted in June (Tables 1 and 2). Overall, elite cultivars, IT90K-277-2, IT93K-734, IT93K-452-1 and IT93K-513-2 performed better, whereas IT86D-719, IAR-48 and Dan Ila gave the poorest yields, when unsprayed. Furthermore, two insecticide sprays increased grain yield significantly ($P < 0.001$, Mann-Whitney test) at all planting dates (Tables 1 and 2). The difference was most pronounced in late July and August planting dates. Increase in grain yield over no protection were 35%, 112% and 995% for 13 June, 27 June, and 23 July 1996 planting, respectively. In 1997 the increases were 141%, 83%, 131% and 861% for cowpea planted on 5

TABLE 1. Grain yield (kg ha^{-1}) of elite cowpea planted at different dates at Minjibir during the 1996 main cropping season

Cultivar	Date of planting				
	13-6-96	27-6-96	23-7-96	12-8-96	Mean
Unprotected					
IT93K-452-1	824	1336	285	95	635
IT90K-277-2	719	868	15	125	451
IT89KD-374-57	707	592	40	97	358
IT87D-941-1	527	533	212	98	343
IT86D-719	578	436	52	5	268
IAR-48	631	174	13	6	206
Mean	667	657	103	71	377
(LSD 5% = 58)					
Protected					
IT93K-452-1	876	2,030	1,215	-	1,374
IT90K-277-2	1,203	1,318	1,003	-	1,175
IT89KD-374-57	776	1,456	1,152	-	1,128
IT87D-941-1	885	1,436	1,020	-	1,114
IT86D-719	901	1,196	1,193	-	947
IAR-48	751	904	1,187	-	947
Mean	899	1,390	1,128	-	1,139
(LSD 5% =168)					

June, 29 June, 15 July, 31 July and 12 August, respectively. For both protected and unprotected cowpea, planting in the last week of June appeared to give the best performance (Tables 1 and 2).

Incidence and abundance of the cowpea aphid, *A. craccivora* at different planting dates and on different cowpea cultivars are presented in Tables 3 and 4. The present study indicates that only cowpea planted between the first week of June and 15 July were infested by aphids. Also, infestation was significantly ($P < 0.01$) higher on cowpea planted in last week of June than that planted in early June and July. Moreover, some elite cultivars including IT93K-452-1, IT93K-734, IT93K-273-2-1 and IT93K-513-2 were found to possess some degree of resistance to the aphid whilst IAR-48, IT86D-719 and Dan Ila showed high susceptibility to attack by the aphid (Table 4). Infestation of both flower buds (racemes) and flowers by *M. sjostedti* increased significantly ($P < 0.01$) with the date of planting (Table 5). Late planted cowpea (August in particular) was found to be attacked by significantly higher number of thrips on IAR-48 and IT86D-719 in 1996 and IT93K-452-1 and Dan Ila in 1997 whereas IT89kd-374-57 and IT90K-277-2 were least infested in both years. The mean number of legume pod borer, *M. vitrata* larvae per flower as well as the proportion of flowers infested and/or damaged differed significantly ($P < 0.001$) between planting dates. Early planted (June) cowpea had the least whilst late planted (July and August) had the

TABLE 2. Grain yield (kg ha^{-1}) of elite cowpea planted at different dates at Minjibir, Kano, during the main cropping season in 1997

Cultivar	Date of planting					
	5-6-97	29-6-97	15-7-97	31-7-97	12-8-97	Mean
Unprotected						
IT90K 277-2	627	1573	539	356	64	632
IT93K 734	447	1024	1097	317	149	607
IT93k 513-2	527	653	620	302	156	451
IT93K 452-1	508	679	535	200	89	402
IT93K 273-2-1	455	956	344	49	16	364
IT93K 596-9-12	487	671	274	170	165	353
IT89KD 374-57	345	592	337	263	69	321
IT87D 941-1	484	583	269	152	36	305
IT94K 410-1	327	596	336	76	68	280
IAR-48	414	511	47	69	84	225
IT86D 719	348	344	101	61	14	174
Dan Ila (Local)	20	106	144	393	274	187
Mean	416	691	387	201	99	385
(LSD 5% = 118)						
Protected						
IT90K 277-2	1441	1786	1163	1230	1215	1367
IT93K 734	1303	1385	1502	1168	1132	1298
IT93K 273-2-1	1402	1568	1580	870	863	1256
IT93K 513-2	1103	2002	733	1003	1096	1187
IAR-48	1540	1292	595	969	911	1061
IT93K 452-1	1203	1143	1208	954	742	1050
IT93K 596-9-12	952	1652	820	881	910	1043
IT89KD 374-57	1106	1036	871	1083	1102	1039
IT87D 941-1	907	1385	797	610	932	926
IT94K 410-1	967	1000	1019	818	794	920
IT86D 719	894	461	307	746	828	667
Dan Ila (Local)	259	476	138	841	791	500
Mean	1004	1265	894	931	951	1026
(LSD 5% = 186)						

highest infestation in 1996. However, in 1997 infestation was significantly higher ($P<0.001$) on cowpea planted in June than that of July and August (Table 6).

Unusually, *M. vitrata* populations declined considerably in July and August 1997 after an initial high infestation in June. Across planting dates, significant differences were observed between cultivars with respect to the proportion of flowers infested in 1996. Generally, IT89KD-374-57 appeared to be the most susceptible whilst IT86D-719 was least attacked by *M. vitrata.*. The

TABLE 3. Effect of date of planting on the incidence and abundance of *Aphis craccivora* on cowpea at Minjibir, Kano, northern Nigeria

Date of planting	Aphid score ±SE[1]	Per cent ± SE of plants infested
13-6-96	0.71±0.23	0.46±0.15
27-6-96	5.35±0.32	21.18±3.04
23-7-96	0	0
12-8-96	0	0
LSD (5%)	0.79	6.04
5-6-97	4.18±0.30	20.37±1.89
29-6-97	6.83±0.10	63.12±2.31
15-7-97	6.42±0.20	38.00±2.86
31-7-97	0	0
12-8-97	0	0
LSD (5%)	0.66	7.30

[1]Means severity of infestation (i.e., visual rating of the extent of infestation) using the following rating scale: 0 = no aphid; 1 = 1 – 4 aphids; 3 = 5 – 20 aphids; 5 = 21 – 100 aphids; 7 = 101 – 500 aphids and 9 = > 500 aphids (Jackai and Singh, 1988)

TABLE 4. Susceptibility of cowpea cultivars to natural infestation by *Aphis craccivora* at Minjibir, Kano State, northern Nigeria

Cultivar	Aphid score ± SE[1]	Percent ± SE of plants infested
1996		
IT93K 452-1	1.8±0.6	2.5±0.8
IT90K 277-2	2.6±0.7	3.9±1.3
IT87D 941-1	2.5±0.6	5.8±1.6
IT89KD 374-57	2.7±0.6	5.9±1.9
IT86D 719	4.2±0.9	22.0±6.7
IAR-48	4.5±1.0	24.8±6.7
LSD (5%)	2.1	11.3
1997		
IT93K 452-1	4.0±0.4	18.7±2.8
IT93K 734	4.4±0.4	26.9±4.0
IT93K 273-2-1	4.9±0.4	20.8±3.8
IT93K 513-2	4.8±0.4	28.0±4.0
IT596-9-12	4.8±0.5	25.5±3.3
IT90K 277-2	5.0±0.4	27.7±3.7
IT87D 941-1	5.4±0.4	36.1±4.2
IT89KD 374-57	5.7±0.4	44.5±5.5
IT94K 410-1	5.9±0.5	46.8±5.8
IT86D 719	7.4±0.5	70.3±6.2
IAR-48	7.8±0.3	70.3±6.2
Dan Ila (Local)	7.7±0.3	71.8±6.2
LSD (5%0	1.15	20.5

[1]Means severity of infestation using the following rating scale: 0 = no aphid; 1 = 14 aphids; 3 = 5 – 20 aphids; 5 = 21 – 100 aphids; 7 = 101 – 500 aphids and 9 = > 500 aphids (Jackai and Singh, 1988)

pod-sucking bug species encountered in this study were *C. tomentosicollis, M. jaculus, N. viridula* and *A. curvipes* of which *C. tomentosicollis* was the most abundant (i.e., constituted > 95% of the pod-sucking bugs). Their numbers were very low at the beginning of the season in both years but increased significantly with planting date (Table 7). Late planted cowpea which flowered and podded from late September to October had the highest infestation and damage by pod-sucking bugs. Cultivar x planting date interactions were significant for these parameters: days to flowering, days to 50% maturity, grain yield and insect pests infestation for both years. Two insecticide application at bud initiation (32 – 36 days after planting) and 50% flowering (42 – 46 days after planting) stages significantly ($P < 0.01$) reduced the population densities of all the post-flowering pests of cowpea (Tables 5, 6 and 7) and increased grain yields considerably (Tables 1 and 2). Partial budgeting and Benefit/Cost analysis indicated that the insecticide application was more profitable on cowpea planted in late July and August (Table 8).

DISCUSSION

The present study has shown that the yield of cowpea in Kano area depends on the cultivar, date of planting and whether protected or unprotected.

TABLE 5. Abundance of *Megalurothrips sjostedti* on cowpea planted at different dates at Minjibir, Kano State, northern Nigeria

Date of planting	Mean number ± SE of thrips per raceme		Mean number ± SE of thrips per flower	
	No spray	Spray	No spray	Spray
13-6-96	0.02±0.10	0.0	1.14±0.20	0.09±0.03
27-6-96	0.42±0.09	0.0	2.42±0.30	0.37±0.07
23-7-96	0.67±0.13	0.1	3.01±0.30	1.08±0.10
12-8-96	2.28±0.53	-	17.17±2.00	1.08±0.10
LSD (5%)	0.87		1.25	0.20
5-6-97	0.16±0.02	0.04±0.01	0.33±0.03	0.08±0.01
29-6-97	0.51±0.06	0.01±0	3.58±0.31	0.37±0.07
15-7-97	0.58±0.05	0.01±0	4.57±0.32	0.26±0.04
31-7-97	0.50±0.04	0.01±0	3.43±0.18	0.81±0.13
12-8-97	0.86±0.07	0.05±0.01	5.92±0.33	0.41±0.06
LSD (5%)	0.14	0.02	0.73	0.07

TABLE 6. Abundance of *Maruca vitrata* on cowpea planted at different dates at Minjibir, Kano State, northern Nigeria

Date of planting	Mean number ± SE of larvae per flower		Proportion (%)±SE of flowers infested by larvae	
	No spray	Spray	No spray	Spray
13-6-96	0.33±0.06	0.09±0.03	32.0±2.6	9.7±1.4
27-6-96	0.57±0.04	0.18±0.02	45.5±3.5	17.5±2.7
23-7-96	0.92±0.07	0.51±0.06	69.3±4.1	41.7±4.2
12-8-96	0.79±0.10	-	66.1±2.5	-
LSD (5%)	0.08	0.05	6.75	4.47
5-6-97	0.56±0.03	0.20±0.03	46.6±2.1	17.5±1.4
29-6-97	0.37±0.02	0.06±0.01	55.0±1.7	8.2±0.9
15-7-97	0.22±0.02	0.04±0.01	28.9±1.7	2.8±0.3
31-7-97	0.35±0.03	0.11±0.01	29.7±1.9	4.6±0.5
12-8-97	0.13±0.02	0.05±0.01	24.0±1.3	7.2±0.6
LSD (5%)	0.06	0.04	4.88	2.30

Elite cowpeas from IITA breeding programme performed better in terms of grain yield when it was planted between Mid-June and Mid-July without insecticide protection. On the other hand, the local cultivar, Dan Ila, produced higher grain yield when planted between late July and early August (Tables 1 and 2). This might be due to the fact that the elite cultivars are determinate, early to medium maturing and non photosensitive. In addition, some of these elite cultivars exhibited field resistance to *A. craccivora*. Therefore, when planted in June or early July, their flowering and podding stages escaped the peak population densities of the three major post flowering pests which occur from mid-September through to November (Asante, unpublished). This is in agreement with Aingbohungbe (1982) who reported that cowpea planted in June or July in Southern Nigeria usually escapes several major pests. However, the flowering and pod formation stages of late planted (July and August) crops coincide with the peak population densities of the three major post-flowering pests resulting in considerable reduction of grain yield. On the

TABLE 7. Abundance of pod-sucking bugs (PSBs)[1] on cowpea planted at different dates at Minjibir, Kano State, Northern Nigeria

Date of planting	Mean number ± SE of adults and nymphs of PSBs[1] per meter row of cowpea	
	No spray	Spray
13-6-96	0.86±0.2	0.16±0.04
27-6-96	1.10±0.2	0.56±0.16
23-7-96	1.04±0.2	0.46±0.09
12-8-96	2.56±0.4	-
LSD (5%)	0.48	0.29
5-6-97	0.38±0.1	0.14±0.01
29-6-97	0.43±0.1	0.04±0.01
15-7-97	0.93±0.2	0.31±0.10
31-7-97	1.90±0.2	1.47±0.20
12-8-97	2.19±0.2	2.47±0.20
LSD (5%)	0.53	0.38

[1]Means *Clavigralla tomentosicollis, Mirperus jaculus, Nezara viridula* and *Anoplocnemis curvipes*

TABLE 8. Profit (Naira and Dollars) per hectare and Benefit/Cost ratios obtained from cowpea planted at different dates under two insecticide sprays

Year	Date of planting	Grain yield (kg ha^{-1})		Profit per hectare		Benefit/cost ratio[2]
		No spray	Spray	(U$)1	Naira	
1996	13-6-96	667	899	5,143	64	2.4
	27-6-96	657	1390	25,633	320	7.9
	23-7-96	103	1128	35,221	440	10.5
	12-8-096*	71	-	-	-	-
1997	5-6-97	416	1004	19,820	242	6.4
	29-6-97	691	1265	19,260	235	6.2
	15-7-97	387	894	16,580	202	5.5
	31-7-97	201	931	25,500	311	7.9
	12-8-97	99	951	30,380	370	9.2

[1]Exchange rate at time of study: N 80 = U$ 1
[2]Benefit/Cost ratio is the number of times the chemical control cost was recouped from the value of the increased yield.
* No yield data was recorded for the spray treatment

other hand, the local cultivar is highly susceptible to aphid attack in addition to being photosensitive and therefore did not flower until September (Table 9) when populations of all the three post flowering pests were at their peak thereby suffering considerable damage.

The low grain yield of the local cultivars particularly when planted in June might be attributed partly to the fact that it used most of the available energy for vegetative growth from June until flowering began in September. Improved cultivars and alteration in planting dates of crops have been used or reported as an effective strategy in reducing pest damage by a number of researchers (Sherman and Todd, 1938; Knippling, 1979; Akingbohungbe, 1982; Ekesi *et al.*, 1996; Prasad and Singh, 1997; Karungi *et al.*, 2000a). The temporal desynchronisation between the host plant development and pest population build-up creates a situation which allows the host to escape substantial damage. In the United States, for example, temporal asynchrony through manipulation of planting dates has provided a good measure of control of the Hessian fly on wheat (Knippling, 1979). Also, planting date has been shown to influence damage to southern peas by *Chalcodermus aeneus* (Sherman and Todd, 1938). Perrin and Ezueh (1978) found that cowpea planted in June and July in southern Nigeria suffered greater damage by *Cydia ptychora* (Merick) than those planted earlier or much later in the dry season. Results from studies conducted at Mokwa in the middle-belt of Nigeria showed that when cowpeas are planted in July, they are likely to mature before peak infestation by *C. tometosicollis* (IITA, 1982).

It has also been stated that planting date manipulation is probably the most promising approach to the control of pod-sucking bugs at present, because of the difficulty in finding resistance to the cowpea hemipteran complex (Jackai, unpublished). Also, Ekesi *et al.* (1996) observed in Zaria, northern Nigeria that *M. vitrata* infested more flowers and pods of cowpea planted in August than those planted in July, and grain yield also decreased significantly in late planted than in early planted cowpea.

Early researchers recommended that six to seven weekly sprays starting a few days after seedling emergence are needed to control cowpea pests (Booker, 1965; Rahejia, 1976). However, it has been reported that more than 70% of total loss in yield of cowpea attributable to insect is a result of damage during the flower and pod formation stages (Kyamanywa, 1996; Karungi *et al.*, 2000b, c). Afun *et al.* (1991) indicated that three sprays at bud formation, flowering and podding will provide adequate protection for cowpea in the absence of pre-flowering insect pests. Karungi *et al.* (2000b) also recommended three sprays, at

TABLE 9. Effect of date of planting on the flowering of improved and local cowpea cultivars

Cowpea cultivar	Days to 50% flowering under different planting dates[1]					
	5-6-97	29-6-97	15-7-97	31-7-97	12-8-97	LSD 5%
IT93K 596-9-12	51.7	44.3	43.0	46.0	44.0	2.5
IT90K 277-2	50.3	46.3	45.0	48.0	48.7	1.8
IT89KD 374-57	56.7	48.7	46.3	49.0	48.3	1.3
IAR-48	49.7	47.0	46.0	47.0	47.7	1.8
IT93K 452-1	41.7	39.7	38.7	39.3	40.7	1.7
IT87D 941-1	49.7	47.3	44.3	47.0	46.3	3.4
IT93K 513-2	50.7	42.0	42.7	47.0	46.3	4.6
IT93K 734	44.7	43.7	46.0	47.3	48.3	2.6
IT86D 719	46.3	46.3	47.7	48.0	50.7	2.3
IT94K 410-1	44.7	44.0	48.3	47.7	48.7	1.1
IT93K 273-2-1	48.7	42.3	43.0	47.0	48.0	2.2
Dan Ila (Local)	84.0	60.0	48.0	50.3	52.0	1.1
LSD (5%)	2.97	1.85	1.58	2.10	1.36	
CV (%)	3.33	2.37	2.10	2.66	1.70	

[1]The cowpea was not sprayed with insecticide

budding, flowering and podding. In the northern Sudan savanna zone of Nigeria, pre-flowering insect pests such as foliage beetles, leafhoppers and bean stem flies are considered as sporadic and minor pests. The only important pre-flowering pest in this ecological zone is *A. craccivora* but our study has shown that some of these improved cultivars possess genes that confer resistance to this aphid species (Table 4). We have therefore demonstrated in our study that instead of 3 sprays recommended by Afun *et al.* (1991) and Karungi *et al.* (2000b), 2 applications, one at bud initiation and another at 50% flowering stages could control post-flowering pests on elite and early maturing cultivars and produce economic yields. Karungi *et al.* (2000b) observed that the critical period to apply foliar insecticide sprays against cowpea field pests is at budding, principally to control thrips infestation. Partial budgeting and benefit/cost analysis indicated that the insecticide applications was more profitable on late planted (late July to August) cowpea than early planting. This suggests that it will be more profitable for a farmer who could afford to spray only twice to delay planting till late July. This will also ensure clean seeds since the cowpea will mature towards the end of the rainy season (or beginning of the dry season).

However, in locations where *C. tomentosicollis* could attain high population densities in October such as Gumel, two sprays may not be able to control them. Furthermore, the present study suggests that farmers in this ecological zone who do not have the resources to buy insecticides could plant improved, early maturing aphid and bruchid resistant cowpea cultivars between 15 and 30 June (if rainfall permits) to achieve maximum economic yield. Akingbohungbe (1982) also suggested that for small farm holders in Southern Nigeria, who are unlikely to apply insecticides, planting in June is advisable. Therefore, efforts should be made by the International Institute of Tropical Agriculture (IITA) to incorporate genes for resistance to aphids and bruchids into elite and early maturing cowpea in their breeding programme.

ACKNOWLEDGEMENTS

We thank Ibrahim Mina, Garba M. Bala, Kamilu Isa and Chi-chi Ogbonna for technical assistance. We are grateful to Dr. B.B. Singh, Cowpea Breeder, International Institute of Tropical Agriculture (IITA) for providing the cowpea cultivars.

REFERENCES

Afun, J.V.K., Jackai, L.E.N. and Hodgson, C.J. 1991. Calendar and monitored insecticide application for the control of cowpea pests. *Crop Protection* 10:363 - 370.

Akingbohungbe, A.E. 1982. Seasonal variation in cowpea crop performance at Ile-Ife, Nigeria and the relationship to insect damage. *Insect Science and its Application* 3:287 - 296.

Amatobi, C.I. 1994. Field evaluation of some insecticides for the control of insect pests of cowpea (*Vigna unguiculata* (L.) Walp) in the Sudan Savanna of Nigeria. *International Journal of Pest Management* 40:13 - 17.

Amatobi, C.I. 1995. Insecticide application for economic production of cowpea grains in the Northern Sudan Savanna of Nigeria. *International Journal of Pest Management* 41:14 - 18.

Booker, R.H. 1996. Pests of cowpea and their control in northern Nigeria. *Bulletin of Entomological Research* 55:663 - 672.

Akesi, S., Dike, M.C. and Ogunlana, M.O. 1996. Relationship between planting dates and damage by the legume pod-borer, *Maruca testulalis* (Geyer) (Lepidotera: Pyralidae) on cowpea *Vigna unguiculata* L. Walp). in Nigeria. *Inernational Journal of Pest Management* 42:315 - 316.

Hammond, W.N.O. 1983. The ecology of pod sucking bugs of cowpea (*Vigna unguiculata* Walp.) with special reference to *Clavigralla* species and their host range in Nigeria. M. Sc. Thesis, University of Ghana, Legon, Ghana.

International Institute of Tropical Agriculture (IITA), 1982. *Annual report*. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Jackai, L.E.N., Singh, S.R., Raheja, A.K. and Wiedijk, F. 1985. Recent trends in the control of cowpea pests in Africa. In: *Cowpea Research, Production and Utilization*. Singh, S.R. and Rachie, K. O. (Eds), pp. 233 - 243. Chickester, John Wiley and Sons, U.K.

Jackai, L.E.N. and Daoust, R.A. 1986. Insect pests of cowpea. *Annual Review of Entomology* 31:9 - 19.

Jackai, L.E.N. and Singh, S.R. 1988. Screening techniques for host plant resistance to insect pests of cowpea. *Tropical Grain Legume Bulletin* 35:2 -18.

Karungi, J., Nampala, M.P., Adipala, E., Kyamanywa, S. and Ogenga-Latigo, M.W. 1999. Population dynamics of selected cowpea insect pests as influenced by different management practices in eastern Uganda. *African Crop Science Journal* 7:487-495.

Karungi, J., Adipala, E., Ogenga-Latigo, M.W., Kyamanywa, S. and Oyobo, N. 2000a. Pest management in cowpea. Part 1. Influence of planting time and plant density on cowpea field pests infestation in eastern Uganda. *Crop Protection* 19:231-236.

Karungi, J., Adipala, E., Kyamanywa, S., Ogenga-Latigo, M.W., Oyobo, N. and Jackai, L.E.N. 2000b. Pest management in cowpea. Part 2. Integrating planting time, plant density and insecticide application for management of cowpea field insect pests in eastern Uganda. *Crop Protection* 19:237-245.

Karungi, J., Adipala, E., Nampala, P., Ogenga-Latigo, M.W. and Kyamnywa, S. 2000c. Pest management in cowpea. Part 3. Quantifying the effect of cowpea field pests on grain yields in eastern Uganda. *Crop Protection* 19:343 - 347.

Knippling, R.F. 1979. The basic principles of insect population suppression and management. United States Department of Agriculture (USDA). *Agricultural Handbook* 512:397 - 401.

Kyamanywa, S. 1996. Influence of time of insecticide application on control of insect pests of cowpea and grain yield at Mtwapa, coastal province of Kenya. *African Crop Science Journal* 4:373- 382.

Mortimore, M.J., Sing, B.B., Harris, F. and Blade, S.F. 1997. Cowpea in traditional cropping systems. In: *Advances in Cowpea Research*. Singh, B.B., Mohan Raj, D.R., Dashiell, K.E. and Jackai, L.E.N. (Eds.), pp. 99 - 113. Sayce Publishing, Devon, UK.

Nampala, P., Ogenga-Latigo, M.W., Kyamanywa, S., Adipala, E., Karungi, J., Oyobo, N., Obuo, J.E. and Jackai, L.E.N. 1999. Integrated management of major field pests of cowpea in eastern Uganda. *African Crop Science Journal* 7:479-486.

Perrin, R.M. and Ezueh, M.I. 1978. The biology and control of grain legume *Olethreutids* (Tortricidae). In: *Pests of Grain Legumes: Ecology and Control.* Singh, S.R., van Emden, H.F. and Ajibola Taylor, T. (Eds.), pp. 201 – 217. Academic Press, London.

Prasa, C.S. and Singh, V.P. 1997. Impact of variety, sowing date and control measures on incidence of pod borer, *Helicoverpa armigera* (Hub.) and yield of chickpea. *Annals of Plant Protection Sciences* 5:26 - 28.

Rachie, K.O. 1985. Introduction. In: *Cowpea Research Production and Utilization*. Singh, S.R. and Rachie, K.O. (Eds.). Wiley and Sons, London.

Raheja, A.K. 1976. Assessment of losses caused by insect pests to cowpea in northern Nigeria. *PANS* 22:229 - 233.

Sherman, F. and Todd, J.N. 1938. Cowpea curculio. *South Carolina Agricultural Experiment Station Annual Report* 51:71 - 75.

Singh, S.R. and van Emden, H.F. 1979. Insect pests of grain legumes. *Annual Review of Entomology* 24:255 - 278.

Singh, S.R. and Allen, D.J. 1980. Pests, diseases, resistance and protection in cowpea. In: *Advances in Legume Science.* Summerfield, R.J. and Bunting, H.H. (Eds.), pp. 419 – 433. Royal Botanical Garden, Kew, Ministry of Agriculture, Fisheries and Food, London.

Singh, S.R., Jackai, L.E.N., Dos Santos, J.H. and Adalla, C.B. 1990. Insect pess of cowpea. In: *Insect pests of Tropical Food Legumes.* Singh, S.R. (Eds.), pp. 43 - 89. John Wiley and Sons, Chichester, U.K.

Taylor, T. and Ezedinma, F.O.C. 1964. Preliminary investigations on field pests of cowpea and methods of control. Federal Department of Agricultural research Memorandum No. 51, Ibadan, Nigeria.